Termite Pests and their Control in Urban Brazil

by

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ABSTRACT

A survey was developed on the inspection data sheets of 500 buildings in the city of São Paulo, in the southeast region of Brazil. Infestation by the introduced subterranean termite, *Coptotermes havilandi*, predominates and aerial nests were found in 42,7% of the infested buildings. The urban infestation by *C. havilandi* is analyzed as a dynamic system in the complexity of the urban areas in Brazil, influenced by building patterns, urban trees, biological peculiarities of the termite, and control measures. The termite interacts largely with the urban ecosystem and it is necessary to understand this dynamic system for each specific infestation case in order to be able to choose the right control strategy.

INTRODUCTION

Termite control is challenge everywhere. For Brazilian pest control professionals this is a particularly difficult task. Tropical climate enhances species diversity and encourages biological processes. In urban areas, damage is caused mainly by species of the genera *Coptotermes*, *Heterotermes*, *Nasutitermes* and *Cryptotermes*, although a number of species of other genera are also reported as pests.

Pest control operators deal with different species, with different behaviors and scarce knowledge of their biology and pest status. Our most economically important termite, *Coptotermes havilandi* Holmgren, is an exotic species that seems to be less important in other countries where it was also introduced. Just recently researches started on this problem in Brazil. Most of the actual knowledge was built on a practical basis by pest control operators, and the problem only recently was approached scientifically by investigators that worked directly with the practice of pest control (Fontes 1995; Milano 1998).

This paper discusses some aspects of termite control in the urban areas of Brazil, focusing on the subterranean termite, *Coptotermes havilandi*. This species is continuously spreading towards new cities and enlarging its geographic distribution in the country. It is the most aggressive termite and the most difficult species to control.

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THE TERMITE PROBLEM IN THE URBAN AREAS

The Example of the Southeast Region

The rapid urbanization and vertical growing of the most important Brazilian cities eliminates species and creates a lot of new microhabitats, some of which are available to pest termites.

To evaluate the relative importance of different wood pests, a survey was developed on the inspection data sheets of 500 buildings (original data from PPV company) infested by wood pests, in the city of São Paulo (the largest city in Brazil and the second largest one in Latin America), from 1996 to 2000. Results are shown in Table 1.

Table 1. Pests of wood in 500 buildings in the city of São Paulo, from 1996 to 2000.

	Wood Borers	Drywood Termites	Subterranean Termites
Buildings	51	59	420
Percentage	10.2%	11.8%	84.0%

It is clear that subterranean termites are the most important pests to wood in São Paulo city. In the survey, 417 infestations were caused by *Coptotermes havilandi*. Only 3 infestations caused by an *Heterotermes* sp. were found. This may be an undescribed species of *Heterotermes*, originally from the Brazilian fauna and recently introduced into urban areas. We agree that instead of describing it as a new species, it is wise to wait until further studies are conducted, in order to determine if the new urban pest (we know of other infestations caused by the same species, after this survey was finished) is not an exotic, imported species. Among the drywood termites, *Cryptotermes brevis* was the most common species. Figures for other large cities in the southeast region of the country, like Rio de Janeiro, are probably similar.

The presence of *Coptotermes havilandi* in Brazil, was first detected in the beginning of the last century in the port cities of Santos and Rio de Janeiro (Fontes & Araujo 1999). The problems with this species increased quickly only some 25 or 30 years ago. In the last 3 decades, the main cities of the SE greatly expanded, with important verticalization of the urban profile. The subterranean termites success, probably evolved as a response to the complexity of the urban structure and dynamics. It now constitutes the most important pest of structural wood, buildings and urban trees.

Coptotermes havilandi Infestation on Buildings

Brazilian building practices are very variable and create a number of conditions that facilitate termite infestation and make control more

difficult. A remarkable feature is the frequent presence of many voids inside large brick buildings, for acoustic or thermal insulation, passage of water, gas and electric pipes, or just for aesthetic reasons, in accordance to a given building style. The stories, for example, can be separated by double floors. The walls inside the voids are commonly lined with wooden molds and, once closed, the voids comprise humid and undisturbed environments, adequate for the development of pest termite colonies (Figs. 1-2). Other large cavities, commonly containing wood, constructive debris and wood molds, are found below stairs, steps, porches, auditoriums, stadium stands and raised floors. (Figs. 3-4). Electric, telephone conduits, water and gas pipes, besides commonly running inside vertical shafts and horizontal voids between the building stories (Fig. 5), are also extensively buried in grooves excavated in the walls and floors. Nowadays, walls are commonly built with hollow brick blocks. All these hollows and passages, added by other narrow openings and cracks that are common in the walls and floors of brick buildings, allow easy access of termites to all building stories and to cellulose materials hidden in the structure or in contact with the walls. So, subterranean termites can heavily attack a building without any external evidence in early stages of infestation.

The constructive process of the subterranean stories of a building create adequate conditions for termite infestation as well, since large amounts of wooden forms are always left in the soil, and subterranean cavities always remain around the area.

Another problem of many Brazilian cities is the dense urban profile, with buildings very close or whose walls touch each other, with no space between them. Indeed, there is always a small space, adequate for the installation and spreading of the subterranean termite.

There are 3 ways a building can be infested by subterranean termites: (1) invasion from a colony located in the soil, either below the built area or coming from the outside; (2) when buildings are constructed side by side and the walls join together, termites can enter the non-infested building through the walls, either close to the soil or at the upper stories (aerial invasion); and (3) by swarming alates that can install a new colony in the soil or in aerial structures. The last process will always result in a discreet initial infestation, which will be diagnosed only in the distant future (more than 5 years, as a rule) or, if earlier, unintentionally. Conversely, alternatives (1) and (2) may result in severe infestation in a very short time and cause a precocious alert, but this is not always a rule.

The swarming alates can reach the higher parts of large buildings, and aerial infestations will develop with no direct contact with the

Fig. 1. Large nest of *C. havilandi* inside a structural void in the 10th story of a building. Part of a water pipe is visible in the right corner. Wooden molds are visible on the top, floor and at rear, and molds fragments on the right. São Paulo, Brazil 17.X.1997.

Fig. 2. Large nest of *C. havilandi* being removed from a structural void in the roof of the 14th story of a residential building. São Paulo, Brazil 20.X.1998.

Fig. 3. Nest of *C. havilandi* in the large cavity below the stands of a sport stadium, under the suspended concrete slab. São Paulo, Brazil IX.1997.

Fig. 4. Nest of *C. havilandi* in the same large of cavity of nest in Fig. 3, over the soil as an epigeous mound. Note a vertical piece of wood surrounded by the nest. São Paulo, Brazil IX.1997.

Fig. 5. Carton structure of *C. havilandi* in the base of a lamp hanged in the roof of building. The electric cables and a hanging spring, arising from a void in the roof, were completely covered by carton. São Paulo, Brazil.

ground. This seems to be fairly common in buildings under construction, since the construction process of large buildings in Brazil demands as long as 2 or 3 years, thus exposing the intimate structure of the building (full of large cavities and debris, wooden forms and wastes) to 2 or 3 consecutive swarming periods, that extend from July to December or longer. It is very common that wooden forms are abandoned inside the sealed cavities of the building, thus providing food for the starting colonies, until they are some years old and capable of exploring the surroundings and expanding the infestation towards the upper and lower adjoining stories.

The upper stories of older buildings can also be infested by royal couples, installed after swarmings. Particularly favorable conditions are presented by structural aerial flower vases and by large aerial flower beds at the balconies, high corners and along the top walls. They provide a good amount of organic soil, humidity, roots and are commonly supported by hollow brick boxes, which can hide a voluminous termite nest.

According to the constructive patterns that changed considerably in the course of the decades, it seems that the wooden forms and constructive remains left inside the sealed voids and below the ground floor can provide nourishment for the colony for 10 or more years. For example, in the buildings of the 60's and 70's, with a very large amount of discarded materials left inside the built structure, it happened that the aerial colonies, founded by a royal pair after the nuptial flight and installed inside voids during construction, were commonly diagnosed later, when the buildings were 10 to 15 years old and presented severe aerial infestations caused by mature colonies producing alates. As the number of termites in the colony (and their demand for food) increases exponentially, and the supply of wood and wood debris in the structural voids diminishes also exponentially, termite activity is diagnosed only when they exploit largely the building, searching for food in distant places and attacking exposed pieces of wood or making their tunnels in visible places. When this happens, commonly a big colony is found that is several years old. Young aerial colonies commonly remain undiagnosed and are seldom encountered. As a case example, we observed in 1999 a 5 year old residential building in the city of São Paulo, with an attack of *C. havilandi* in one of the two apartments of the 15th floor, at the top of the building. The infestation was unexpectedly found in the course of a renovation. When the suspended cabinets of the kitchen were removed, the termites were attacking the back of the cabinets and were also discovered in the ceilings of the kitchen and laundry. No external signs of termite activity were visible, neither at that story nor

in the rest of the building. The nest was discovered at the building's roof and the termites were damaging the woods in the roof structure.

To evaluate the relative importance of aerial nests, the inspection data sheets of 420 buildings infested by *Coptotermes havilandi*, referred in Table 1, were analyzed. Results are shown in Table 2.

Table 2. Distribution of *Coptotermes havilandi* nests in 420 large buildings in the city of São Paulo, from 1996 to 2000. The category ground + aerial includes both buildings with two independent colonies (aerial and ground colonies), as aerial colonies that are satellites of ground colonies.

Site of Nest :	Ground	Aerial	Ground + Aerial	Total
Nr. Buildings	241	91	88	420
Percentage	57,4%	21,7%	21,0%	100,0%

While ground infestation predominates (57,4%), aerial nests were found in 42,7% of the infested buildings, and pure aerial infestation of *Coptotermes havilandi* occurred in almost 22% of the buildings. This picture is different from that presented by Su & Scheffrahn (1987), in that 86% of the buildings infested by *Coptotermes formosanus* were invaded from colonies located in the ground. On the other hand, our data is similar to those of Tamashiro *et al*. (1987), who estimate that over 50% of the high rises in Waikiki, Hawaii, have been infested by aerial colonies of *C. formosanus*, and of Lin (1987), who reports that about 50% of the *C. formosanus* infestations in urban areas of China have aerial nests.

Problems on the Control of *Coptotermes havilandi*

Most of the control procedures applied in Brazil were adapted from American and European standards. The four basic strategies (soil treatments, wood treatments, foundation treatments and mechanical alterations) are also adopted in Brazil by the pest control technicians with few adaptations, although they may not be enough to control some infestations typical of the Brazilian building patterns. This is especially true for *Coptotermes havilandi*.

The frequent occurrence of pure aerial infestation pose a particular difficulty on control, since soil treatments or ground baits will not affect the termite colony. This condition requires a careful evaluation of the built structure and/or a complexity of control measures, in order to extinguish the infestation. Also, aerial infestations may be responsible for many unsuccessful control operations in Brazil. as described for Miami, by Su *et al*. (1997) where the pest control firms probably had mistaken the infestation for native subterranean termites and had

applied insecticide in the soil annually for five consecutive years, without affecting the infestation by *C. havilandi*. Many similar cases occurred (and continue to occur) in São Paulo, where chemical barriers applied in the soil were ignored by *C. havilandi* aerial infestations.

An extreme consequence (despite being common in São Paulo) of perimeter chemical soil treatments applied along the inner and/or outer walls of large built areas is the relative isolation of the colonies installed inside by the chemical barriers, restricting their activity to the inside the built area. Poor inspections and inadequate evaluation of the infestation, allied with incorrect management of soil treatments, will definitely stimulate the colony to disseminate upwards and install aerial infestations in buildings previously having only the ground floor infested.

Infestation of large urban trees is another problem of particular importance. Urban trees are an important reservoir of *C. havilandi* in the great cities of the SE region of Brazil (Fontes 1995 & 1998; Fontes & Araujo 1999). Trees severely damaged by termites provoke a drastic response of house owners and municipality authorities: they cut down the trees at ground level and the subterranean part of the trunk and the roots are simply concealed by soil and the cement floor. The termite colony, disturbed by the removal operation and partly deprived of food, commonly invade the surrounding buildings and houses, and the medium term result is a dramatic spread and increase of the infestations. The voluminous tree remains hidden in the soil are a permanent focus of recurring infestations, in spite of repeated perimeter treatments of the built sites. We reported in 1996 a room 15 m^2 at the side edge of a one story brick building, severely infested by *C. havilandi*. A voluminous and sound eucalyptus trunk, more than 1.20 cm in diameter at the breast level and about 7 m from the room's outer wall, was also infested. Our initial control recommendation was the removal of the trunk, but this was refused by the board of directors of that public institution due to the operation difficulties and costs of the removal. Thus, the floor of the room received a careful perimeter treatment with chemical insecticide, applied by perforations each 30 cm, as well as the surrounding outer cemented pavement. Infestation recurred after 6 months, and a new treatment was applied, reinforced by an additional row of perforations, only 20 cm away from the previous rows. Thus, the chemical soil barrier was composed by a double infiltration of the soil, inside and outside the built area, and insecticide was also spread abundantly over the under surface of the floor. About 6 months after, a new recurrence demanded a more intensive treatment, reinforced by perforations in the whole floor surface inside the room. This treatment

had to be repeated after 4 to 6 months, due to a new reinfestation. After 2 years the board of directors finally decided to remove the tree trunk. The trunk was removed with part of the roots, excavated to the depth of 1.50 m. A voluminous subterranean nest of *C. havilandi* was found in the depth of the roots and the wood, well perforated by the termite, was still very sound. Then, the built area received chemical treatment, similar to the last one performed, as well as the soil pit, and the termite infestation disappeared.

According to our practical experience on control of *C. havilandi* infestations, chemical treatments of nests inside structural voids are frequently ineffective. Unless the nest is perforated and chemicals are applied directly inside the chambers and are enough to penetrate a substantial portion of the nest, the colony will remain alive. In 2000, we removed an aerial nest from a void chemically treated 1 year before, but the colony was sound, despite several areas near the nest surface being uninhabited and isolated from the living nest by closed chambers (Milano, Fontes & Gouveia, unpublished). Another nest (Fig.1-2 in Fontes 1995), inside an empty vertical shaft 0.15 x 0.20 x 2 meters, received more than 60 liters of liquid insecticide and remained alive, despite some 30 to 40 cm of the top of the nest were abandoned by the termite (E. Sayegh, personal information). Another practice, forbidden by Brazilian government regulations, is the use of fumigants (commonly phosphin, although methyl bromide is also used) to treat nests inside structural voids. In 1992, we removed a nest with a healthy *C. havilandi* population from a void that 2 months before was submitted to fumigation with phosphin, according to reliable information of the customer.

Large buildings and complex built structures, even when carefully inspected, are not infrequently submitted to control measures that do not eliminate the infestation immediately. Sometimes, the work performed result in the fragmentation of a termite colony. Large population fragments can survive for long periods and can migrate through the building, as far as 6 months or more and demand additional control measures, or at least a very good explanation to the customer, who will seldom be willing to wait the natural death of the fragment population. See the next item below for an example of the ability of a fragment population of *C. havilandi* surviving under unusual circumstances. We can state that in 10 to 20% of the cases more than one control intervention is necessary. The initial control operations will reduce drastically the infestation, but the undiagnosed nests and the large populations of foragers that are spread throughout the building, remain unaffected by the control measures and can survive for months inside the building. A good post-treatment inspection and a monitoring

schedule is always desirable until control is definitely achieved.

Inadequate control measures (mainly application of chemicals, and sometimes also mechanical alterations) are not uncommonly proposed by nonspecialized or badly prepared pest control companies in the southeast region. Incorrect treatments cause stress to the termite colony and the common consequences are (a) the spread of the infestation to other areas, (b) the fragmentation of the colonies, and (c) the apparent disappearance of the termites and the false impression of control, with recurrence in the near future of a much heavier infestation, whose control is more difficult and more expensive.

A *Coptotermes havilandi* infestation interacts actively with the building structure and must be seen as a dynamic system, permanently expanding, retracting and changing the infestation picture, especially if the colony is submitted to some stress (like a partial chemical control operation). The main or only way to control the termite is to understand how the termite-building system works. In a broad sense, we consider that the "building" is not restricted to the constructive area, but composed also of the surroundings, to an extent variable according to each practical condition, as the subterranean termite interacts largely with the urban ecosystem (Fontes 1995; Fontes & Araujo 1999). It is necessary to understand this dynamic system for each specific infestation case, in order to be able to choose the right control strategy (Milano 1998).

Is Neoteny an Important Feature in *Coptotermes havilandi* Colonies?

Coptotermes havilandi colonies are polycalic and live in divided nests (primary nest plus a variable number of subsidiary or satellite nests). A colony can start as aerial and expand through aerial satellite nests (pure aerial infestation), or reach the soil and install satellite nests also in the ground level. Conversely, a colony primarily installed in the soil can reach the upper parts of a building and construct aerial satellite nests. Thus, aerial and ground nests can be primary or subsidiary nests. They can be a mass of carton material with no reproductives and eggs, or they can have a pair of primary reproductives. In a few cases the occurrence of neotenic reproductives was reported (Lelis 1995 & 1999; Costa-Leonardo *et al.* 1999). All of these conditions may occur even if the nests are very big.

Very few records of reproductives in *Coptotermes havilandi* colonies are available. Lelis described 3 aerial nests, one having an imaginal queen and two neotenic males (1995), one with an imaginal royal pair and one, in which no male was collected, with a neotenic queen (1999).

Costa-Leonardo *et al.* (1999) described 2 aerial nests, one with an imaginal royal pair and 20 neotenics, and one (considered to be a satellite of the previous nest) with 32 neotenic reproductives.

Milano & Gouveia (unpublished) examined about 100 nests in detail. Most were masses of carton (sometimes more than 50 liters in volume) with no reproductives or egg chambers. In many cases, eggs and larvae were found, but there were no signs of a royal pair or royal chamber. Eight nests, of pure aerial infestations, had reproductives: 7 were primary queens and 1 was a substitutive queen with residual wing buds and small eyes. The nest shown in Figure 2 was removed from the 14th

Fig. 6. Physogastric queen of *C. havilandi*, collected in the nest shown in Fig. 2.

story of a residential building and had a primary queen (Fig. 6).

It is interesting that 4 of the 5 nests with neotenic reproductives (Lelis 1995; Costa-Leonardo *et al.* 1999; Milano & Gouveia, unpublished) were removed from buildings that received unsuccessful treatment against termites for several months until effective control of the infestation was obtained. The development of neotenics in *C. havilandi* seems therefore to be a response to a long-term stress, imposed by repeated unsuccessful control measures that eventually isolated the satellite nests and/or orphaned the primary colony.

It was experimentally demonstrated that orphaning can induce the production of replacement reproductives in some termites (see Costa-Leonardo *et al.* 1998), including 2 mound building species of *Coptotermes* from Australia (Lenz & Barrett 1982; Lenz, Barrett & Miller 1986). The case reported below was not a guided experiment and can be compared to a practical field treatment, in that a well populated nest is submitted to prolonged environmental and dietary restrictions, with occasional fragmentation and orphaning of the colony.

A nest of *C. havilandi* was collected inside a cavity in the groundfloor of a building in the city of São Paulo, in October 2000. A 27 liter nest fragment was enclosed within two plastic bags and unintentionally kept

inside a hatchback car. The car was driven for 6.5 months, until the nest was finally discovered and explored. The termites had perforated the plastic bags, built covered tunnels and damaged parts of the car carpets. The population was large and consisted of soldiers, large

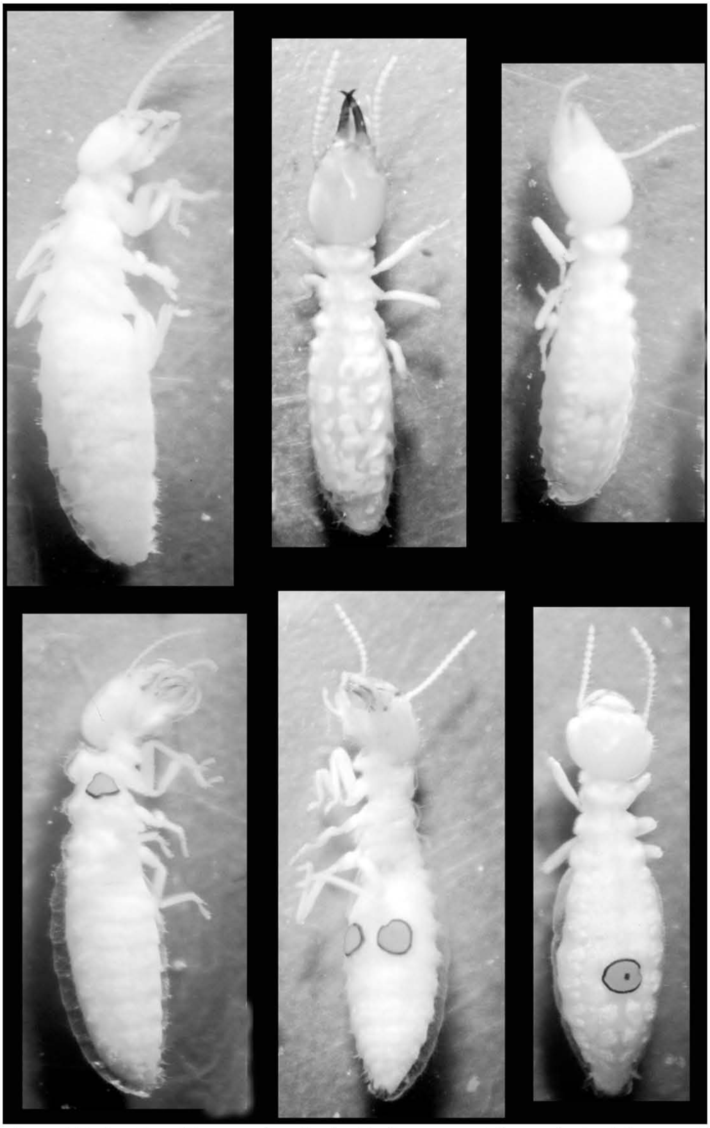

Fig. 7. Castes of *C. havilandi* in a nest collected in the ground floor of a building and kept for 6.5 months inside a car. Upper row, from left to right: nymph, soldier, white soldier. Lower row: workers with parasitic fungi. São Paulo, Brazil X.2000.

mature workers and very few young nymphs and white soldiers (Fig. 7). No eggs, larvae, younger workers or reproductives were found. It was clear that the colony survived the stress and, despite the large population, the workers continued to molt but do not developed into ergatoid reproductives. Soldiers continued to be produced, as white soldiers were present. We sampled the workers by chance and found that 45 (19,9%) out of the 226 workers collected had parasite fungi in the cuticle (probably a species of the genus *Termitaria*), in the form of large plates surrounded by a dark colored ring, in the worker abdomen and thorax. This kind of fungal parasitism was unusually high, when compared to field populations.

The presence of substitutive reproductives in *C. havilandi* seems to be an exception and represent a peculiar response to the stress of control procedures (orphaning or isolation of satellite nests). When present, they seem to originate from nymphs. Their presence is probably of scarce, if of any importance for the control of *C. havilandi* infestations in the southeast region of Brazil.

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